TECHNICAL PAPER

# STANDARDIZED UXO DEMONSTRATION SITES

## G-TEK AUSTRALIA PTY LIMITED MAN-PORTABLE TM-5EMU DETECTOR SYSTEM - *BLIND GRID SCORING RECORD NO. 183*

The TM-5EMU EM
as demonstrated by G-TEK Australia PTY Limited.

***The TM-5EMU EM data acquisition system is a lightweight, digital electromagnetic detector and data logger designed for the difficult terrain usually encountered in UXO and environmental surveys. The TM-5EMU EM was demonstrated in the Aberdeen Proving Ground Blind Grid Area by G-TEK Australia PTY Limited. This technical paper contains the results of that demonstration. This technical paper is a reference document only and does not serve as an endorsement of the demonstrator's product by the US Army or the Standardized UXO Technology Demonstration Sites Program.***

Technologies under development for the detection and discrimination of unexploded ordnance (UXO) require testing so that their performance can be characterized. To that end, standardized test sites have been developed at Aberdeen Proving Ground, Maryland, and Yuma Proving Ground, Arizona. These test sites provide a diversity of geology, climate, terrain, and weather as well as diversity in ordnance and clutter. Testing at these sites is independently administered and analyzed by the government for the purposes of characterizing technologies, tracking performance with system development, comparing performance of different systems, and comparing performance in different environments.

The Standardized UXO Technology Demonstration Site Program is a multi-agency program spearheaded by the US Army Environmental Center. The US Army Aberdeen Test Center and the US Army Corps of Engineers Engineering Research and Development Center provide programmatic support. The program is being funded and supported by the Environmental Security Technology Certification Program, the Strategic Environmental Research and Development Program, and the Army Environmental Quality Technology Program.

## DEMONSTRATOR'S SYSTEM AND DATA PROCESSING DESCRIPTION

The man-portable TM-5EMU consists of a magnetometer control module; multi-period, transient electromagnetic (EM) sensors; digital Global Positioning System (DGPS); and an odometer. The TM-5EMU EM detector system may be configured with one or two sensors measuring the transient EM response. In the application proposed, two sensors will be mounted in an array, oriented perpendicularly to the survey direction and delivering a 1.2-meter swath width. In the sensor array mode, the TM-5EMU is operated by a single person.

The TM-5EMU interfaces with both industry standard real-time kinetic (RTK) DGPS and proprietary cotton thread-based odometer systems providing versatile positioning adaptable to varied terrain and vegetation conditions. It has been used successfully for over five years. The odometer remains the positioning technology of choice in adverse terrains; DGPS is preferred in open environments. Combined, they meet the requirements of most situations.

The TM-5EMU user interface provides a continuous set of data quality monitors. There are audio and graphic displays and alarms monitoring sensor signal quality and position data quality. A key attribute of the TM-5EMU is its virtual immunity to hot rocks.

Using G-TEK's EMUDAS field data acquisition software, up to two sensors of two-channel EM data will be recorded at 32 Hz in DGPS mode and 5 cm in

cotton odometer distance-mode and the GPS positions (at no less than 1 Hz) will be transformed in real time into the required coordinate system. Then in cotton odometer mode, the precise vertices of the survey boundary and control lines are measured with the RTK-DGPS and entered into the TM-5EMU EM. Once collected, the GPS and EM data will be merged on the 32 Hz timebase in real time. Drift corrections are then applied using EMUDAS. When operated in distance mode, no date merging is required. Following the merge and drift corrections, data will automatically be assigned unique line numbers during the data acquisition and the data will be indexed by these line numbers during the line-based processing (i.e., up to the gridding stage). Extraneous data will be either automatically or manually flagged as not required. The positions of the individual sensors will be calculated from the precisely measured sensor GPS antenna offsets and the instantaneous track direction of the array. These individual sensor track positions will be referenced as sub-lines 1 to 2 (note that in distance mode this stage is automated). Finally, all data will be transferred from the field device to the processing computer and a Field Data Sheet will be completed by each crew leader.

The raw data will be exported to Geosoft ASCII x-y-z format and written to CD for submission. The data will then be refiducialled to a distance-base of no greater than 0.05 meter to facilitate band-pass filtering to reduce effects with wavelengths determined to be inconsistent with the target anomalies (e.g., radio interference). Both channels of data will be gridded to a square mesh no greater than 0.05 meter, using minimum curvature gridding with a maximum tension of 1 and using the Geosoft FLOAT grid format. Data will then be loaded into the viewing and interpretation software for semi-automated interpretation. This process involves the automatic selection of positive and negative maximums and which amplitudes exceed the interpretation thresholds. These selections are then manually checked and amended. Parameters from the selected anomalies are then determined for use in an automated rule-based discrimination procedure. Use will be made of the ground-truth data from the calibration lane to fine-tune the discrimination settings.

Information on the selected anomalies (processed data) will then be imported into a spreadsheet for formatting for presentation as a digsheet. The digsheet data (processed data) will be reformatted to comply with the processed data submittal guidelines on the Standardized UXO Technology Demonstration Site-Submission for Scoring Web site. Anomaly parameters such as peak amplitude and width at half-amplitude in the north to south and east to west directions will be captured. These parameters will then be used in a rule-based discrimination system for the discrimination classification and prioritization in the submittal.

## Performance Summary

Results for the Blind Grid test, broken out by size, depth, and nonstandard ordnance, are presented in the table below. Results by size and depth include both standard and nonstandard ordnance. The results by size show how well the demonstrator did at detecting/discriminating ordnance of a certain caliber range. The results are relative to the number of ordnances emplaced. Depth is measured from the closest point of anomaly to the ground surface.

The Response Stage results are derived from the list of anomalies above the demonstrator-provided noise level. The results for the Discrimination Stage are derived from the demonstrator's recommended threshold for optimizing UXO field cleanup by minimizing false digs and maximizing ordnance recovery. The lower 90-percent confidence limit on probability of detection and probability of false positives was calculated assuming that the number of detections and false positives are binomially distributed random variables. All results have been rounded to protect the ground truth. However, lower confidence limits were calculated using actual results.

## Blind Grid Scoring Summary

| Metric | Overall | Standard | Nonstandard | By Size | | | By Depth, m | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Small | Medium | Large | < 0.3 | 0.3 to <1 | >= 1 |
| **RESPONSE STAGE** | | | | | | | | | |
| $P_d$ | 0.75 | 0.80 | 0.70 | 0.80 | 0.75 | 0.80 | 0.95 | 0.75 | 0.35 |
| $P_d$ Low 90% Conf | 0.70 | 0.74 | 0.56 | 0.68 | 0.61 | 0.55 | 0.84 | 0.63 | 0.19 |
| $P_{fp}$ | 0.90 | - | - | - | - | - | 0.90 | 0.85 | 1.00 |
| $P_{fp}$ Low 90% Conf | 0.83 | - | - | - | - | - | 0.84 | 0.74 | 0.63 |
| $P_{ba}$ | 0.25 | - | - | - | - | - | - | - | - |
| **DISCRIMINATION STAGE** | | | | | | | | | |
| $P_d$ | 0.50 | 0.55 | 0.45 | 0.55 | 0.45 | 0.50 | 0.55 | 0.60 | 0.30 |
| $P_d$ Low 90% Conf | 0.44 | 0.45 | 0.34 | 0.46 | 0.33 | 0.27 | 0.44 | 0.45 | 0.13 |
| $P_{fp}$ | 0.60 | - | - | - | - | - | 0.50 | 0.70 | 0.80 |
| $P_{fp}$ Low 90% Conf | 0.54 | - | - | - | - | - | 0.39 | 0.61 | 0.42 |
| $P_{ba}$ | 0.20 | - | - | - | - | - | - | - | - |

Response Stage Noise Level: 16.10
Recommended Discrimination Stage Threshold: 0.50

***Note:*** *The Response Stage noise level and recommended Discrimination Stage threshold values are provided by the demonstrator.*